

Observations of the Moon made at the Radcliffe Observatory, Oxford, during the year 1889; and a Comparison of the Results with the Tabular Places from Hansen's Lunar Tables.
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The present paper contains the observations of the right ascensions and north polar distances of the Moon, made at the Radcliffe Observatory during the year 1889. These results are here compared with those deduced from Hansen's Lunar Tables on two suppositions :—

- (1) That the mean times, found in the usual way from the sidereal times at mean noon, given in the *Nautical Almanac*, were *not* changed in 1864 by the adoption of a different unit of time.
- (2) That these mean times *were* changed in 1864 by the adoption of a different unit of time to fix the positions of the clock stars relatively to the Sun, in accordance with the views which I have explained in papers communicated to the Society.

It will be seen that the mean annual error of Hansen's Tables from 1847 to 1863 is $-1''.30$, and that no law of regular increase is apparent; but that, with the argument in the Tables taken out in the usual way, the mean annual error has since increased at an average rate of $0''.72$ per annum, the error now amounting to more than $+17''$. The mean annual error of Hansen's Tables from 1864 to 1889 taken out with the *corrected* argument is $-1''.36$, which is almost identically the same as the mean error between 1847 and 1863.

For facilities for an accurate comparison between Hansen's Lunar Tables and observations I am again indebted to the places published in the *Connaissance des Temps*.

Radcliffe Observations of the Moon, 1889.

R.A.'s and N.P.D.'s of the Centre of the Moon, compared with Hansen's Tabular Places, Uncorrected and Corrected for the Change in the Unit of Mean Time introduced in the year 1864.

Day, 1889.	Observer.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times.	Hansen <i>minus</i> Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen <i>minus</i> Observed. Corrected.	Correction due to the Change in the Unit of Mean Time.	Hansen <i>minus</i> Observed. Uncorrected.	Hansen <i>minus</i> Observed. Corrected.
		h m s	s	s	s	s	s	s	s
Jan. 12	F. B.	4 14 49.75	50.81	+ 1.06	- 1.24	- 0.18	+ 4.37	- 3.18	+ 1.19
17	F. B.	8 40 36.35	37.74	+ 1.39	- 1.35	+ 0.04	- 3.30	+ 2.78	- 0.52
21	F. B.	12 10 50.80	51.86	+ 1.06	- 1.29	- 0.23	- 7.65	+ 5.62	- 2.03
22	W.	13 2 30.51	31.63	+ 1.12	- 1.30	- 0.18	- 7.90	+ 8.04	+ 0.14
Feb. 7	W.	3 6 57.58	58.62	+ 1.04	- 1.20	- 0.16	+ 5.80	- 6.23	- 0.43
8	R.	3 55 22.32	23.22	+ 0.90	- 1.23	- 0.33	+ 4.83	- 5.29	- 0.46
9	F. B.	4 45 12.04	13.12	+ 1.08	- 1.27	- 0.19	+ 3.64	- 3.06	+ 0.58
11	W.	6 29 50.34	51.24	+ 0.90	- 1.35	- 0.45	+ 0.69	+ 0.29	+ 0.98
12	R.	7 24 9.91	10.76	+ 0.85	- 1.37	- 0.52	- 0.99	+ 0.12	- 0.87
14	W.	9 13 46.91	48.04	+ 1.13	- 1.36	- 0.23	- 4.33	+ 3.17	- 1.16
15	W.	10 7 52.01	53.09	+ 1.08	- 1.34	- 0.26	- 5.77	+ 4.14	- 1.63
16	W.	11 1 6.04	7.28	+ 1.24	- 1.32	- 0.08	- 6.90	+ 4.01	- 2.89
21	R.	15 29 48.44	49.66	+ 1.22	- 1.44	- 0.22	- 6.37	+ 4.48	- 1.89

Day, 1889	Observer.	Observed R.A. h m s	R.A. from Hansen's Tables for Uncor- rected Mean Times.	Hansen minus Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen minus Observed. Corrected.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen minus Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen minus Observed. Corrected.
Feb. 22	R.	16 28 52.32	53.53	+1.21	-1.51	-0.30	108 18 13.51	17.96	+4.45	-4.85	-0.40
Mar. 11	W.	7 0 52.39	53.42	+1.03	-1.35	-0.32	67 45 6.50	6.76	+0.26	-0.30	-0.04
13	R.	8 49 43.60	44.62	+1.02	-1.37	-0.35	70 24 54.50	56.35	+1.85	-3.69	-1.84
15	W.	10 37 56.20	57.23	+1.03	-1.35	-0.32	77 20 56.39	61.89	+5.50	-6.60	-1.10
16	R.	11 31 24.38	25.43	+1.05	-1.34	-0.29	82 5 9.57	14.50	+4.93	-7.61	-2.68
21	F. B.	16 10 19.08	20.61	+1.53	-1.51	+0.02	107 28 39.86	45.27	+5.41	-5.48	-0.07
22	R.	17 11 50.30	51.65	+1.35	-1.56	-0.21	110 30 15.75	17.37	+1.62	-3.53	-1.91
Apr. 15	R.	13 48 29.42	30.41	+0.99	-1.42	-0.43	95 56 2.21	8.80	+6.59	-8.47	-1.88
May 6	R.	8 5 4.96	5.62	+0.66	-1.34	-0.68	68 16 54.71	54.45	-0.26	-2.29	-2.55
16	F. B.	17 24 26.51	28.12	+1.61	-1.67	-0.06	111 19 44.54	49.17	+4.63	-3.42	+1.21
21	R.	22 36 56.08	57.47	+1.39	-1.35	+0.04	103 11 55.80	47.82	-7.98	+6.73	-1.25
June 5	R.	10 22 42.44	42.96	+0.52	-1.29	-0.77	75 33 29.51	31.82	+2.31	-6.05	-3.74
13	F. B.	17 57 19.22	20.85	+1.63	-1.72	-0.09	112 17 12.39	13.87	+1.48	-2.26	-0.78
18	R.	23 10 57.44	58.78	+1.34	-1.34	0.00	100 21 11.08	3.85	-7.23	+7.41	+0.18
July 5	R.	12 35 55.62	56.22	+0.60	-1.28	-0.68	88 7 52.34	58.35	+6.01	-8.06	-2.05
6	F. B.	13 26 50.53	51.50	+0.97	-1.32	-0.35	93 29 25.97	31.06	+5.09	-8.25	-3.16
10	R.	17 22 3.20	4.44	+1.24	-1.68	-0.44	111 15 50.77	53.54	+2.77	-3.60	-0.83
16	R.	23 41 4.26	5.54	+1.28	-1.33	-0.05	97 28 50.38	43.28	-7.10	+7.91	+0.81

Correction to be
subtracted from M.T.
for change of Sidereal
Time at Mean Noon
since 1864.

March 1890. <i>made at the Radcliffe Observatory etc.</i>										291						
Day, 1889.	Observer.	Observed R.A.			Observed N.P.D.	Hansen <i>minus</i> Observed. Corrected.		Correction due to the Change in the Unit of Mean Time.	Hansen <i>minus</i> Observed. Uncorrected.		N.P.D. from Hansen's Tables for Uncorrected Mean Times.					
		<i>h</i>	<i>m</i>	<i>s</i>		<i>s</i>	<i>s</i>									
July 18	R.	1	21	3.63	4.92	+1.29	-1.23	+0.06	87	5	46.20	37.96	-8.24	+7.74	-0.50	Hansen <i>minus</i> Observed. Corrected.
Aug. 5	F. B.	15	52	26.00	27.21	+1.21	-1.50	-0.29	106	37	36.03	41.07	+5.04	-6.20	-1.16	Hansen <i>minus</i> Observed. Uncorrected.
6	R.	16	53	29.67	30.61	+0.94	-1.60	-0.66	110	9	12.33	16.46	+4.13	-4.44	-0.31	
7	F. B.	17	58	10.52	11.69	+1.17	-1.67	-0.50	112	20	52.76	55.18	+2.42	-2.14	+0.28	
Sept. 6	R.	20	48	14.33	15.46	+1.13	-1.60	-0.47	110	23	47.30	42.89	-4.41	+4.38	-0.03	
7	F. B.	21	49	41.74	42.95	+1.21	-1.52	-0.31	106	52	33.47	30.48	-2.99	+6.27	+3.28	
9	W.	23	42	49.89	51.25	+1.36	-1.37	-0.01	97	7	57.95	50.01	-7.94	+8.26	+0.32	
10	W.	0	35	13.52	14.87	+1.35	-1.32	+0.03	91	40	54.84	48.11	-6.73	+8.40	+1.67	
12	F. B.	2	15	38.02	39.39	+1.37	-1.27	+0.10	81	13	36.42	30.55	-5.87	+7.44	+1.57	
15	R.	4	46	29.19	30.20	+1.01	-1.32	-0.31	69	52	49.14	46.88	-2.26	+3.88	+1.62	
16	F. B.	5	38	32.89	34.08	+1.19	-1.35	-0.16	67	51	35.74	35.88	+0.14	+2.32	+2.46	
17	W.	6	31	28.49	29.62	+1.13	-1.36	-0.23	66	53	45.13	44.15	-0.98	+0.64	-0.34	
Oct. 3	W.	20	26	35.69	36.96	+1.27	-1.59	-0.32	111	29	55.63	51.83	-3.80	+3.61	-0.19	
4	R.	21	27	27.02	28.32	+1.30	-1.52	-0.22	108	28	40.62	34.94	-5.68	+5.57	-0.11	
5	F. B.	22	25	17.54	19.03	+1.49	-1.44	+0.05	104	19	63.39	59.59	-3.80	+7.05	+3.25	
7	F. B.	0	12	36.43	37.68	+1.25	-1.32	-0.07	94	3	63.22	57.90	-5.32	+8.41	+3.09	
8	W.	1	3	22.52	23.77	+1.25	-1.29	-0.04	88	36	38.41	31.61	-6.80	+8.35	+1.55	
9	R.	1	53	17.76	18.93	+1.17	-1.28	-0.11	83	19	39.57	32.61	-6.96	+7.88	+0.92	

Day, 1889.	Observer.	Observed R.A.	R.A. from Hansen's Tables for Uncor- rected Mean Times.	Hansen minus Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen minus Observed. Corrected.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen minus Observed. Uncorrected.	Correction due to the Change in the Unit of Mean Time.	Hansen minus Observed. Corrected.
		^h ^m ^s	^s	^s	^s	^s	[°] ['] ["]	["]	["]	["]	["]
Oct. 13	R.	5 16 43.07	44.07	+1.00	-1.35	-0.35	68 19 19.23	18.08	-1.15	+3.03	+1.88
31	W.	21 9 46.52	47.80	+1.28	-1.54	-0.26	109 44 39.59	35.15	-4.44	+5.05	+0.61
Nov. 1	R.	22 7 53.65	54.94	+1.29	-1.45	-0.16	105 55 28.66	23.28	-5.38	+6.63	+1.25
2	F. B.	23 2 38.88	40.25	+1.37	-1.37	0.00	101 15 47.05	42.72	-4.33	+7.67	+3.34
4	W.	0 44 49.44	50.54	+1.10	-1.28	-0.18	90 42 9.39	3.17	-6.22	+8.37	+2.15
8	R.	4 3 34.69	35.87	+1.18	-1.32	-0.14	71 58 30.79	24.24	-6.55	+5.25	-1.30
12	W.	7 35 7.77	9.04	+1.27	-1.37	-0.10	66 42 57.57	57.25	-0.32	-1.42	-1.74
27	R.	20 49 35.38	36.51	+1.13	-1.61	-0.48	110 57 30.34	25.37	-4.97	+4.52	-0.45
28	F. B.	21 50 13.94	15.51	+1.57	-1.50	+0.07	107 24 29.02	23.91	-5.11	+6.32	+1.21
Dec. 2	W.	1 18 34.29	35.33	+1.04	-1.25	-0.21	87 8 48.78	42.72	-6.06	+8.19	+2.13
3	R.	2 6 52.64	53.67	+1.03	-1.25	-0.22	82 1 40.45	34.59	-5.86	+7.67	+1.81
10	W.	8 8 42.74	43.97	+1.23	-1.36	-0.13	67 25 3.58	5.85	+2.27	-2.48	-0.21
31	R.	2 40 22.55	23.44	+0.89	-1.26	-0.37	78 46 8.15	1.01	-7.14	+7.15	+0.01
Mean of Errors, without regard to sign		...	...	^s 1.161	...	^s 0.243	["] 4.342	...	["] 1.322
Mean Errors for Year		...	...	+1.161	...	-0.230	...	...	...	...	...

Observers: W., Mr. W. Wickham; R., Mr. W. H. Robinson; F. B., Mr. F. A. Bellamy.

TABLE II.

*Radcliffe Observations of the Moon, 1889.**Errors of the Moon's Tabular Place in Longitude and Ecliptic Polar Distance, Uncorrected and Corrected for the Change in the Unit of Mean Time introduced in the year 1864.*

Day, 1889.		Errors of Longitude (Hansen minus Observed).		Errors of E.N.P.D. (Hansen minus Observed).	
		Uncorrected.	Corrected.	Uncorrected.	Corrected.
Jan.	12	+ 15 ^{''} 53	— 2 ^{''} 75	— 0 ^{''} 44	+ 0 ^{''} 71
	17	+ 19 ^{''} 68	+ 0 ^{''} 41	— 2 ^{''} 34	— 0 ^{''} 65
	21	+ 16 ^{''} 90	— 3 ^{''} 99	— 1 ^{''} 17	— 0 ^{''} 49
	22	+ 18 ^{''} 64	— 2 ^{''} 44	+ 0 ^{''} 95	+ 1 ^{''} 17
Feb.	7	+ 16 ^{''} 41	— 2 ^{''} 14	— 1 ^{''} 80	— 1 ^{''} 06
	8	+ 13 ^{''} 81	— 4 ^{''} 57	— 2 ^{''} 51	— 1 ^{''} 43
	9	+ 15 ^{''} 61	— 2 ^{''} 75	— 1 ^{''} 10	+ 0 ^{''} 23
	11	+ 12 ^{''} 52	— 6 ^{''} 20	— 0 ^{''} 37	+ 1 ^{''} 31
	12	+ 11 ^{''} 71	— 7 ^{''} 28	— 1 ^{''} 58	+ 0 ^{''} 18
	14	+ 16 ^{''} 31	— 3 ^{''} 47	— 1 ^{''} 77	— 0 ^{''} 13
	15	+ 16 ^{''} 13	— 4 ^{''} 11	— 1 ^{''} 63	— 1 ^{''} 20
	16	+ 18 ^{''} 47	— 2 ^{''} 21	— 3 ^{''} 37	— 2 ^{''} 21
	21	+ 18 ^{''} 33	— 3 ^{''} 57	+ 0 ^{''} 04	— 1 ^{''} 06
	22	+ 17 ^{''} 74	— 4 ^{''} 29	+ 1 ^{''} 72	+ 0 ^{''} 27
	March 11	+ 14 ^{''} 24	— 4 ^{''} 28	— 1 ^{''} 21	+ 0 ^{''} 40
March	13	+ 14 ^{''} 39	— 5 ^{''} 26	— 2 ^{''} 10	— 0 ^{''} 44
	15	+ 16 ^{''} 09	— 4 ^{''} 77	— 0 ^{''} 55	+ 0 ^{''} 73
	16	+ 16 ^{''} 32	— 5 ^{''} 03	— 1 ^{''} 66	— 0 ^{''} 75
	21	+ 22 ^{''} 56	+ 0 ^{''} 27	+ 1 ^{''} 29	— 0 ^{''} 12
	22	+ 19 ^{''} 05	— 3 ^{''} 10	+ 0 ^{''} 04	— 1 ^{''} 66
	April 15	+ 16 ^{''} 21	— 6 ^{''} 69	+ 0 ^{''} 90	+ 0 ^{''} 53
May	6	+ 8 ^{''} 95	— 9 ^{''} 80	— 2 ^{''} 16	— 0 ^{''} 53
	16	+ 22 ^{''} 75	— 0 ^{''} 76	+ 3 ^{''} 22	+ 1 ^{''} 26
	21	+ 21 ^{''} 86	+ 1 ^{''} 01	+ 0 ^{''} 19	— 0 ^{''} 94
June	5	+ 7 ^{''} 89	— 11 ^{''} 81	— 0 ^{''} 59	+ 0 ^{''} 57
	13	+ 22 ^{''} 61	— 1 ^{''} 25	+ 1 ^{''} 38	— 0 ^{''} 77
	18	+ 21 ^{''} 10	— 0 ^{''} 07	+ 1 ^{''} 05	+ 0 ^{''} 17
July	5	+ 10 ^{''} 72	— 10 ^{''} 26	+ 2 ^{''} 00	+ 2 ^{''} 13
	6	+ 15 ^{''} 45	— 6 ^{''} 07	— 0 ^{''} 69	— 0 ^{''} 98
	10	+ 17 ^{''} 47	— 6 ^{''} 19	+ 1 ^{''} 61	— 0 ^{''} 42
	16	+ 20 ^{''} 38	— 1 ^{''} 01	+ 1 ^{''} 07	+ 0 ^{''} 45
	18	+ 21 ^{''} 10	+ 1 ^{''} 03	— 0 ^{''} 39	— 0 ^{''} 13

Day, 1889.		Errors of Longitude (Hansen <i>minus</i> Observed).		Errors of E.N.P.D. (Hansen <i>minus</i> Observed).	
		Uncorrected.	Corrected.	Uncorrected.	Corrected.
Aug.	5	+ 18".12	— 4".33	+ 1".25	— 0".25
	6	+ 13".63	— 9".27	+ 2".61	+ 0".74
	7	+ 16".23	— 6".93	+ 2".36	+ 0".30
Sept.	6	+ 16".49	— 6".36	— 0".01	— 1".79
	7	+ 17".38	— 5".30	+ 3".03	+ 1".59
	9	+ 21".82	— 0".26	+ 0".76	+ 0".23
	10	+ 21".41	— 0".25	+ 1".78	+ 1".72
	12	+ 21".18	+ 0".88	+ 1".19	+ 1".97
	15	+ 14".41	— 4".54	— 0".43	+ 1".05
	16	+ 16".49	— 2".31	+ 0".76	+ 2".37
	17	+ 15".51	— 3".19	— 1".85	— 0".16
Oct.	3	+ 18".14	— 4".30	+ 0".51	— 1".24
	4	+ 19".38	— 2".94	+ 0".42	— 1".09
	5	+ 21".59	— 0".52	+ 4".39	+ 3".29
	7	+ 19".42	— 2".21	+ 2".58	+ 2".43
	8	+ 19".96	— 1".15	+ 0".91	+ 1".20
	9	+ 18".83	— 1".86	— 0".38	+ 0".28
	13	+ 14".01	— 5".01	— 0".09	+ 1".50
	31	+ 18".61	— 3".69	+ 1".09	— 0".50
Nov.	1	+ 19".36	— 2".61	+ 1".52	+ 0".36
	2	+ 20".34	— 1".30	+ 3".79	+ 3".08
	4	+ 17".73	— 3".35	+ 0".74	+ 0".92
	8	+ 17".82	— 1".71	— 3".18	— 1".66
	12	+ 17".23	— 1".64	— 3".15	— 1".49
	27	+ 16".60	— 6".36	— 0".53	— 2".24
	28	+ 22".94	+ 0".54	+ 2".76	+ 1".48
Dec.	2	+ 16".77	— 3".73	+ 0".27	+ 0".78
	3	+ 16".44	— 3".70	— 0".30	+ 0".59
	10	+ 17".15	— 1".81	— 1".37	+ 0".17
	31	+ 14".69	— 5".19	— 2".79	— 1".65
Mean of Errors, without regard to sign ...17".365		3".646	1".447	1".019	
Mean Errors for Year + 17".365		— 3".513			

TABLE III.

Mean Excess over Observation of the Moon's Tabular Place in Longitude for the years 1847 to 1889, as Computed from Hansen's Tables.

Uncorrected and Corrected on and after 1864 for the change in the Unit of Mean Time introduced in the year 1864.

Year.	Errors of Longitude (Hansen minus Observed).	
	Uncorrected.	Corrected.
1847*	+ 1'07	+ 1'07
1848	+ 0'20	+ 0'20
1849	— 0'47	— 0'47
1850	— 0'28	— 0'28
1851	— 1'29	— 1'29
1852	— 0'92	— 0'92
1853	— 1'63	— 1'63
1854	— 1'68	— 1'68
1855	— 0'87	— 0'87
1856	— 0'96	— 0'96
1857	— 1'86	— 1'86
1858	— 1'98	— 1'98
1859	— 1'80	— 1'80
1860	— 2'90	— 2'90
1861	— 2'19	— 2'19
1862	— 2'83	— 2'83
1863	— 1'61	— 1'61
1864	+ 0'12	— 0'81
1865	+ 1'27	— 0'22
1866	+ 2'14	— 0'22
1867	+ 3'48	+ 0'36
1868	+ 4'12	+ 0'28
1869	+ 4'28	— 0'35
1870	+ 4'83	— 0'66
1871	+ 6'96	+ 0'44
1872	+ 7'31	+ 0'10
1873	+ 8'24	+ 0'20
1874	+ 9'29	+ 0'56
1875	+ 9'87	+ 0'36
1876	+ 9'80	— 0'50
1877	+ 9'23	— 1'90
1878	+ 8'22	— 3'60
1879	+ 9'63	— 3'12
1880†	+ 10'89	— 2'77
1881	+ 10'51	— 4'06
1882	+ 12'68	— 2'51
1883‡	+ 14'71	— 1'50
1884	+ 14'65	— 1'91
1885	+ 15'20	— 1'82
1886	+ 15'34	— 2'53
1887	+ 15'70	— 3'25
1888	+ 17'68	— 2'46
1889	+ 17'37	— 3'51

Radcliffe Observatory, Oxford:
1890 March 11.

* 1847 to 1879, Greenwich observations.

† 1880 to 1882, Mean of Greenwich and Radcliffe.

‡ 1883 to 1889, Radcliffe observations.

A New Class of Binary Stars. By Professor Edward C. Pickering.

A study of the photographic spectra of the stars undertaken as a memorial to Dr. Henry Draper has been in progress for several years at the Harvard College Observatory. This has led to the detection of certain binary stars whose components are too close to be separated by ordinary means. Suppose the two components of such a binary to have similar dimensions and identical spectra, and to revolve around each other in a circular orbit whose plane passes near the Sun. When the stars are in conjunction both are moving perpendicular to the line of sight, their spectra will be superposed, and it will be impossible to distinguish them from a single star. After making a quarter of a revolution or at elongation, however, one star will be approaching the observer rapidly, and all the lines in its spectrum will accordingly be moved slightly towards the blue end of the spectrum. The other star will be receding and its lines will be carried towards the red end. The two spectra will thus be separated so that every line will appear double. After another quarter of a revolution the motion will again be perpendicular to the line of sight and the lines will be single. At the next elongation the lines will be again double, but reversed, so that the star which was before approaching is now receding.

The occasional doubling of the K line in the spectrum of ζ *Ursæ Majoris* has already been announced. A careful study was made of this star last autumn. In all 113 photographs have been obtained on 80 nights. These seem to show that the lines became double at intervals of 52 days, corresponding to a period of revolution of 104 days. It now seems probable that the period should be reduced one half. Owing to the low altitude of the star the first photographs were often poor, but now that it rises higher during the night the law regulating the phenomenon will soon be determined. The spectrum is that of the first type in which the principal lines are those due to hydrogen, and are too broad to permit a slight separation to be detected in them. The other lines, except the K line, are very faint, and when double are seen with difficulty. The best photographs, however, show that several of these also are double, the separation being proportional to the wave-length of the line. The maximum separation of the K line somewhat exceeds 0.2 millionth of a millimetre, corresponding to a relative velocity of one star compared with the other of about a hundred miles a second.

A similar case has been discovered by Miss A. C. Maury, who is making a careful study of the spectra of the brighter stars. The star β *Aurigæ*, from 47 photographs on 30 nights, shows a distinct doubling of its lines at intervals of almost exactly two days, indicating a period of revolution of four days. The lines